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Design and Performance Evaluation of A Directional Telescopic Microphone for Enhanced Environmental Sound Capture

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Abstract

A directional telescopic microphone is composed of two parts. One is the pick-up circuit made up of 34 different length aluminum tubes to respond in a specific frequency. The use of a sensitive FET mic is to pick up a sound from a direction. The signal from the FET mic will be feed to the microphone preamplifier in order to amplify the signal. The Equalization and Attenuation circuit is responsible for the balancing and boosting the low and high frequency. The pick-up signal can be easily recordedto a device through the recording unit or can be heard through the speaker, driven by a power amplifier in order to set up the signal. The main purpose of the gadget is to be used in an environmental study. This can pick up sound that was not normally heard by human ear in a specify distance.

Keywords: *Directional Telescopic Microphone, Enhanced Environmental Sound Capture, Sensitive FET Mic, Equalization and Attenuation Circuit*

1. Introduction

Sound plays a pivotal role in the human understanding of the environment and is equally vital for ecological research (Pennypacker& Wood, 2023). Grounding our understanding of the impacts of boreal forest expansion on shallow cumulus clouds with a simple modelling framework.Journal of Hydrometeorology. It serves as a unique medium through which one can gain insights into various natural phenomena. In the domain of environmental studies, there is a growing need to capture and analyze sounds that fall outside the audible spectrum of the human ear. This necessitates the development of specialized audio equipment specifically designed to meet the demands of environmental monitoring (McLellan et al., 2022).

The study introduces an innovative solution to this challenge. This work presents a directional telescopic microphone system meticulously engineered to transcend the limitations of conventional microphones, enabling the precise capture of distant sounds. The microphone system comprises several intricate components, including a pick-up circuit composed of 34 differently sized aluminum tubes optimized for specific frequencies, a sensitive Field-Effect Transistor (FET) microphone for directional sound pickup, a microphone preamplifier for signal amplification, and an Equalization and Attenuation circuit for frequency balancing and boosting (Bevans et al., 2023).

The primary objective of this state-of-the-art gadget is to uncover and record sounds that fall beyond the range of human auditory perception, particularly at distances of specific relevance to environmental studies. This advanced microphone system equips scientists and researchers with the means to explore and analyze acoustic information in the natural world, thereby opening up new dimensions for the study of environmental sound.

This paper delves into the intricate design and operational principles of the directional telescopic microphone and its associated components, emphasizing its significance and potential applications in the realm of environmental science. Additionally, the paper conducts a comprehensive performance evaluation to gauge its capabilities, reliability, and effectiveness. It stands as a valuable resource for those seeking to broaden their comprehension of environmental acoustics and lays the groundwork for innovative sound capture methodologies in the investigation of our natural surroundings.

Significance of the Technology

The study holds paramount significance in several key aspects:

The development of a directional telescopic microphone system represents a substantial advancement in the field of environmental monitoring. It equips scientists and researchers with a specialized tool for capturing sounds in the natural world that were previously beyond the reach of conventional microphones. This technological innovation enables a deeper understanding of ecological systems and phenomena.

By capturing sounds at specific distances that lie outside the range of human auditory perception, this microphone system provides the capability to analyze acoustic data in unprecedented detail. Researchers can delve into the subtle nuances of soundscapes, which can reveal hidden patterns, behaviors, and ecological processes that were previously inaccessible.

The ability to capture distant and subtle sounds is invaluable in ecological studies. It enables the observation of wildlife behaviors, tracking of species migrations, and monitoring of environmental changes with greater precision. This, in turn, supports more accurate and insightful ecological research and conservation efforts.

In an increasingly urbanized world, the microphone system can also find applications in the study of noise pollution. It enables researchers to identify, locate, and mitigate sources of noise pollution more effectively, thereby contributing to the improvement of urban environments and the well-being of inhabitants.

The study opens the door to potential scientific discoveries by revealing previously hidden acoustic data. It may unveil new relationships between soundscapes and environmental factors, helping scientists better understand complex ecosystems, climate changes, and even seismic activities.

Beyond its scientific applications, the directional telescopic microphone can be a valuable educational tool. It can help engage students and the general public in the exploration of natural sounds, fostering a deeper appreciation for the environment and the importance of sound in ecological studies.

The technology can be adopted across various scientific disciplines, promoting collaboration between ecologists, environmental scientists, acoustic engineers, and other experts. This interdisciplinary approach may lead to innovative research and problem-solving in the environmental sciences.

Thus, the study of the directional telescopic microphone system not only represents a significant technological advancement but also has far-reaching implications for environmental research, ecological conservation, and our understanding of the natural world. It offers the potential to uncover hidden soundscapes and contribute to a more comprehensive comprehension of the environment, with broad applications in both scientific and practical contexts.

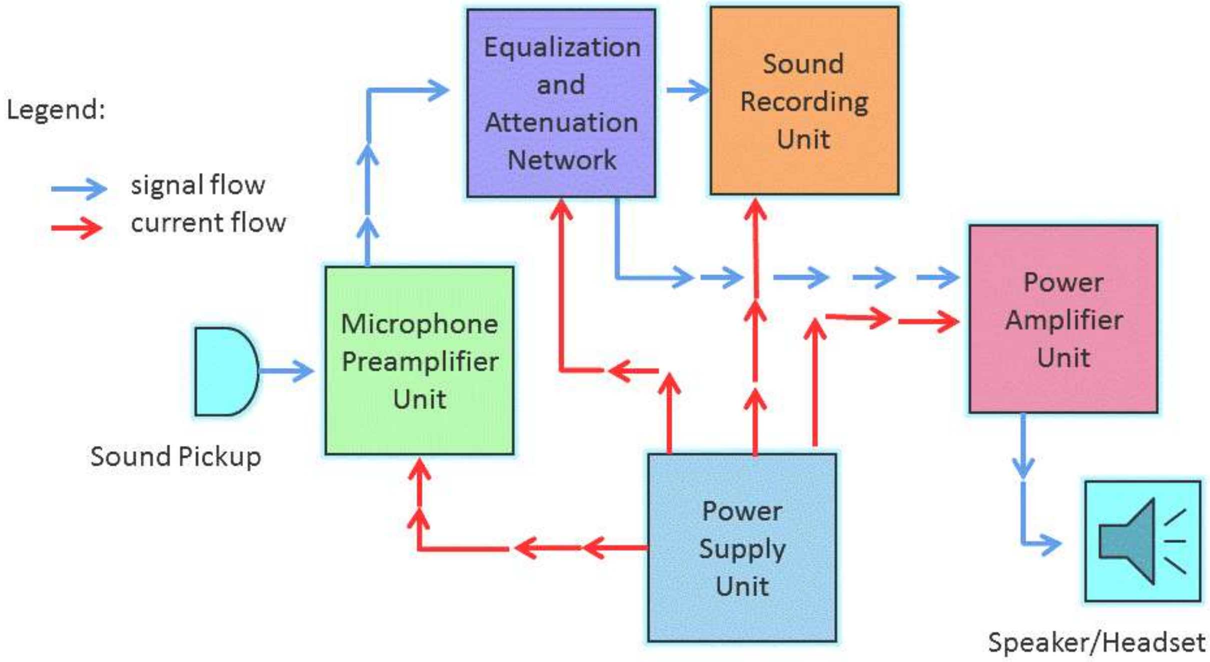


Figure 1. Operational block Diagram of the directional telescopic microphone.

Evaluation of the Study

The directional telescopic microphone was evaluated by establishing a predetermined distance and angle from the sound pick-up unit. Two test planes were created: one perpendicular to the sound pick-up unit and another inclined at a 30° angle. These test planes were spaced at intervals of six meters (96 feet). A test signal, played at approximately 3dB, emanated from a portable audio player and was recorded using a digital recorder. Subsequently, the recorded data underwent analysis through the Fast Fourier Transform (frequency analysis) method, a commonly employed technique for identifying frequency components within a sampled signal that is obscured within a noisy time domain signal.

2. Materials And Methods

Description of the Gadget

The gadget was made from 3/8” aluminum tubing cut into lengths, which was calculated using the formula:

$$\text{Resonance Frequency (KHz)} = \frac{\text{Speed of sound on Air}}{\text{Tube Length x 2}}$$

Where:

Speed of sound in air = 1100ft/sec.

The aluminum tubing was calculated using a formula and cut to respond exclusively to a particular frequency. A total of thirty-four tubes, ranging from one inch to twenty-eight inches in length, were used to construct the waveguide. These tubing pieces were arranged in a helical pattern and securely bonded with epoxy. The sound pick-up unit was then affixed to the rear end of the waveguide and connected to the modulator and amplifier unit, all enclosed within a plastic casing that also housed the power supply.

3. Results and Discussion

Figure 2 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker as shown.The waveform, depicted in red within the figure, represents the visual representation of the original sound marker's signal. The Fast Fourier Transform process dissects this signal, revealing the various frequencies that constitute it. This analysis is instrumental in gaining insights into the composition of the sound, identifying dominant frequencies, and discerning any underlying patterns or variations.

Figure 2.FET analysis of the original sound marker.

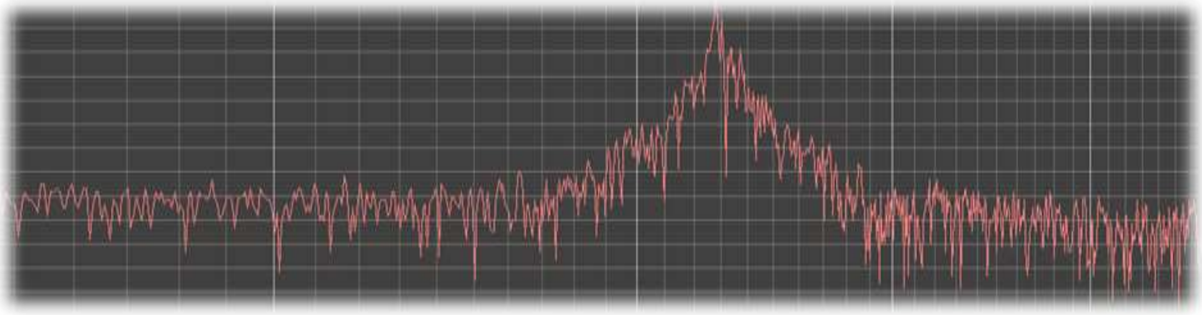


Figure 3 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 10 meters from the microphone pick up unit as shown.Through the FFT process, this time-domain signal is transformed into a frequency-domain spectrum. This spectrum showcases the various frequency components that make up the sound, allowing for a more comprehensive understanding of its acoustic properties. The specific distance of 10 meters from the microphone pick-up unit is a crucial detail in this analysis. It signifies the impact of sound propagation and attenuation over distance. As sound travels through the air, it undergoes changes in intensity and frequency composition. By examining the FFT analysis at this precise distance, researchers can gain insights into how the sound marker's spectral characteristics evolve as it propagates through space.

Figure 3.FET analysis of the results at 10 meters.

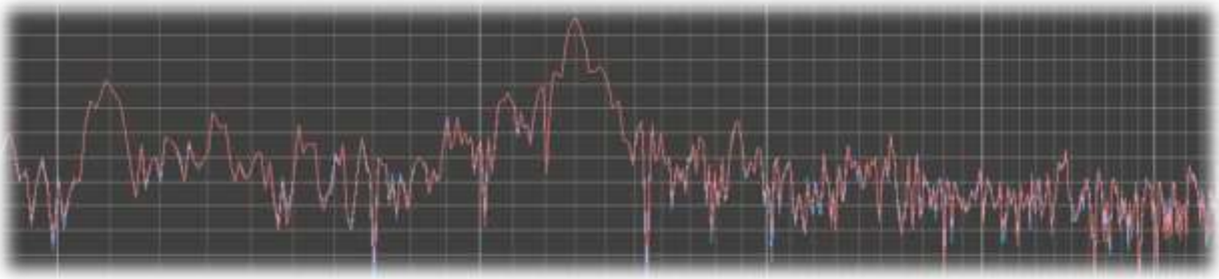


Figure 4 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 16 meters from the microphone pick up unit as shown.The FFT process plays a crucial role here, as it converts the sound's time-domain waveform into a frequency-domain representation. This transformation reveals the constituent frequency components that together form the sound, enabling a thorough examination of its spectral characteristics. The selection of a specific distance, in this case, 16 meters from the microphone pick-up unit, is a critical aspect of the analysis. It accounts for the propagation of sound through space, taking into consideration factors such as sound attenuation and changes in frequency distribution as sound waves travel. By focusing on this precise distance, researchers can observe how the sound marker's spectral properties evolve as it moves away from the source. This has implications for various applications, including environmental sound monitoring, acoustic engineering, and understanding the behavior of sound in diverse environments.

Figure 4. FET analysis of the results at 16 meters.

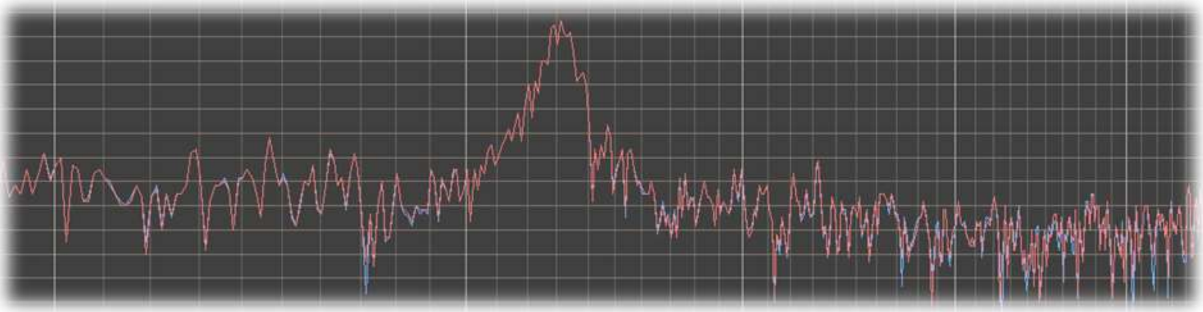


Figure 5 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 22 meters from the microphone pick up unit as shown.The FFT process is instrumental in this context, as it transforms the sound's time-domain waveform into a frequency-domain representation. Through this transformation, the figure illustrates the constituent frequency components that make up the sound, enabling a thorough examination of its spectral characteristics. The selection of a specific distance, precisely 22 meters from the microphone pick-up unit, is a key element of this analysis. This decision takes into account the principles of sound propagation, considering factors such as sound attenuation, changes in frequency distribution, and the potential impact of the surrounding environment on sound propagation. By focusing on this particular distance, researchers can gain insights into how the sound marker's spectral properties evolve as it travels a considerable distance from the source.

Figure 5. FET analysis of the results at 22 meters.

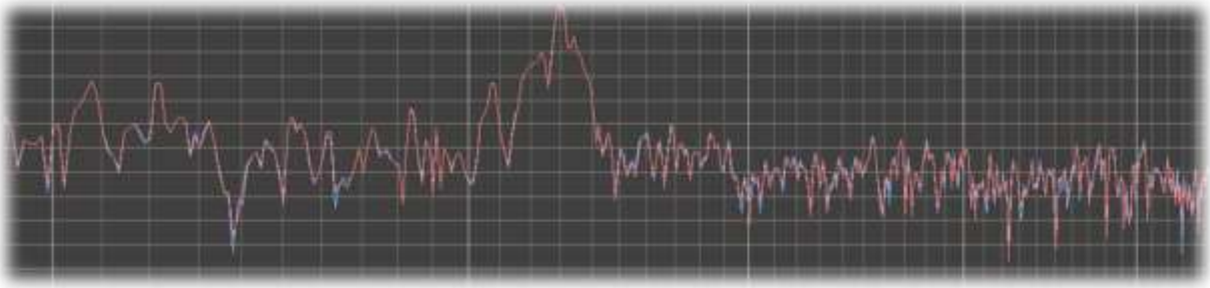


Figure 6 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 28meters from the microphone pick up unit as shown.The FFT process, central to this analysis, transforms the time-domain waveform of the sound into a frequency-domain representation.

Through this transformation, the figure reveals the underlying frequency components that constitute the sound, enabling a detailed examination of its spectral characteristics. The choice of a specific distance – 28 meters in this case – is a critical aspect of the analysis. It takes into account the principles of sound propagation, accounting for factors such as sound attenuation, variations in frequency distribution, and the environmental conditions through which the sound travels. Focusing on this particular distance allows researchers to understand how the sound marker's spectral properties change as it propagates over a considerable distance from the source.

Figure 6.FET analysis of the results at 28 meters.

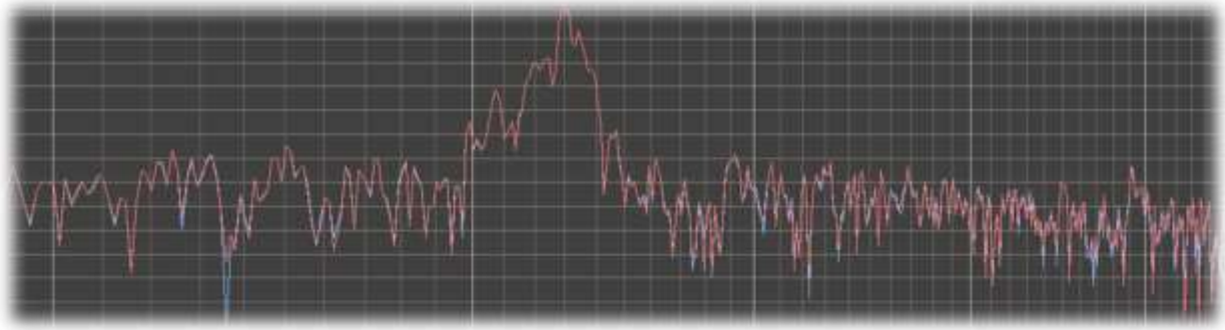


Figure 7 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 34 meters from the microphone pick up unit as shown.

Figure 7.FET analysis of the results at 34 meters.

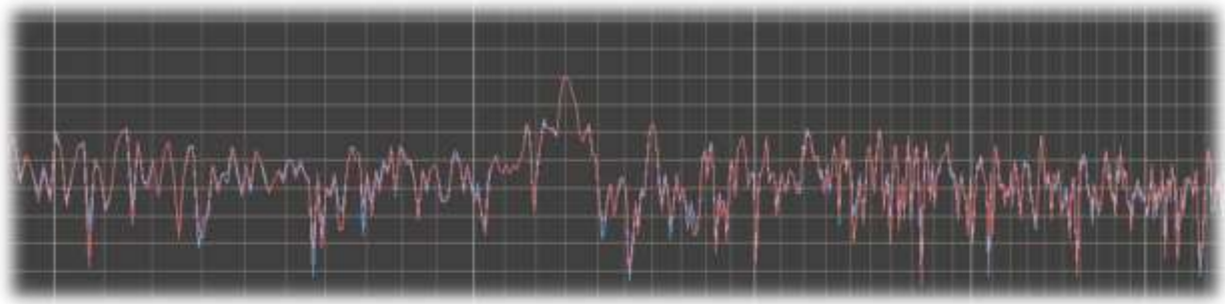


Figure 8 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 40 meters from the microphone pick up unit as shown.

Figure 8.FET analysis of the results at 40 meters.

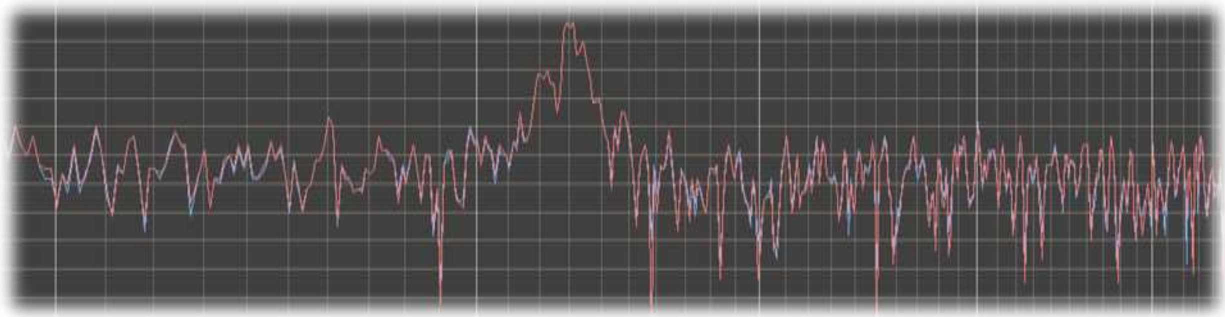


Figure 9 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 50 meters from the microphone pick up unit as shown.

Figure 9.FET analysis of the results at 50 meters.

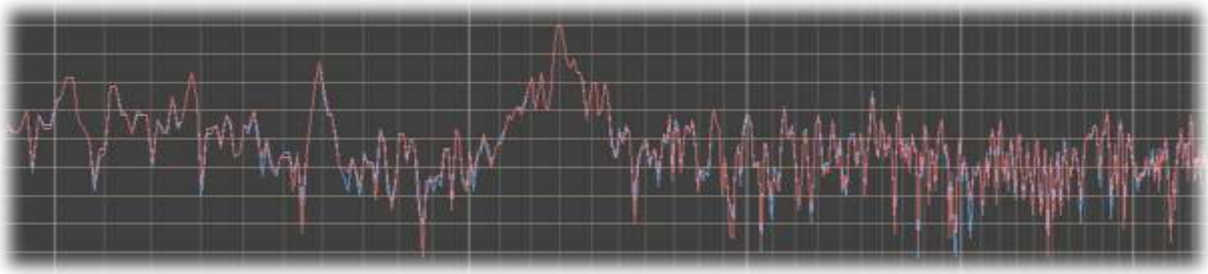


Figure 10 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 75 meters from the microphone pick up unit as shown.

Figure 10.FET analysis of the results at 75 meters.

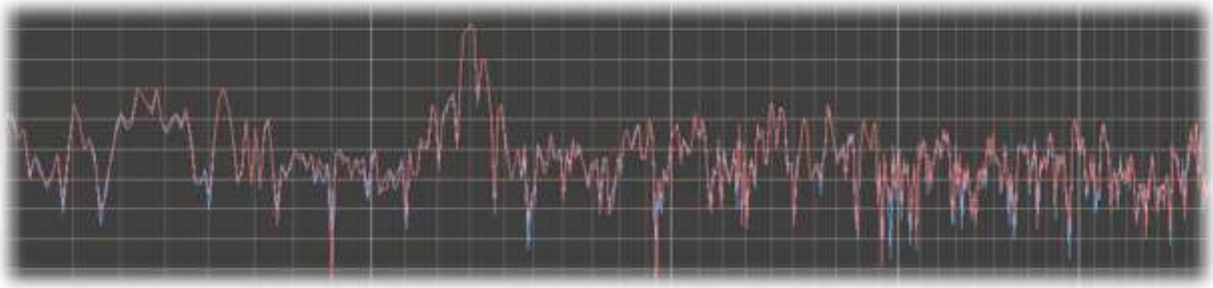


Figure 11 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 100 meters from the microphone pick up unit as shown.

Figure 11.FET analysis of the results at 100 meters.

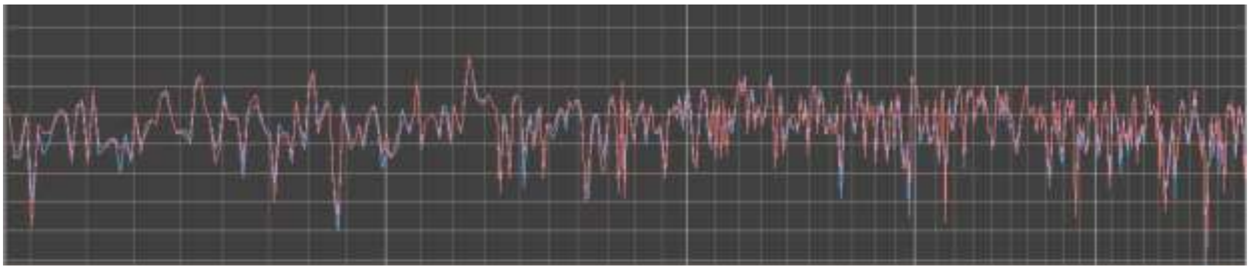


Figure 12 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 16 meters distance 30⁰ left from the microphone pick up unit as shown.

Figure 12. FET analysis of the results at 16 meters 30⁰ left.

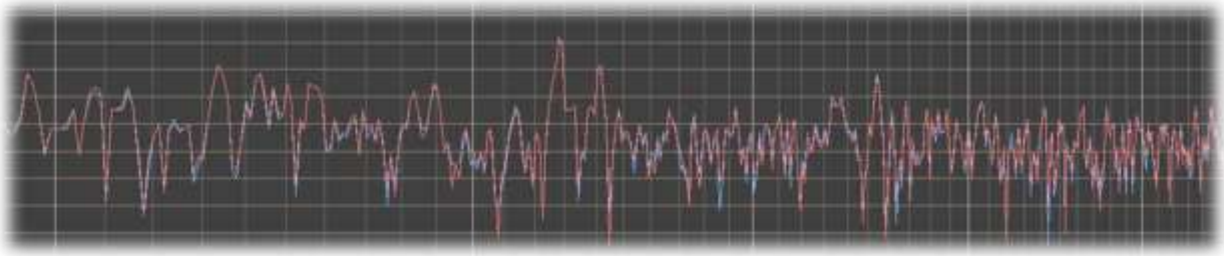


Figure 13 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 16 meters distance 30⁰ right from the microphone pick up unit as shown.

Figure 13. FET analysis of the results at 16 meters 30⁰ right.

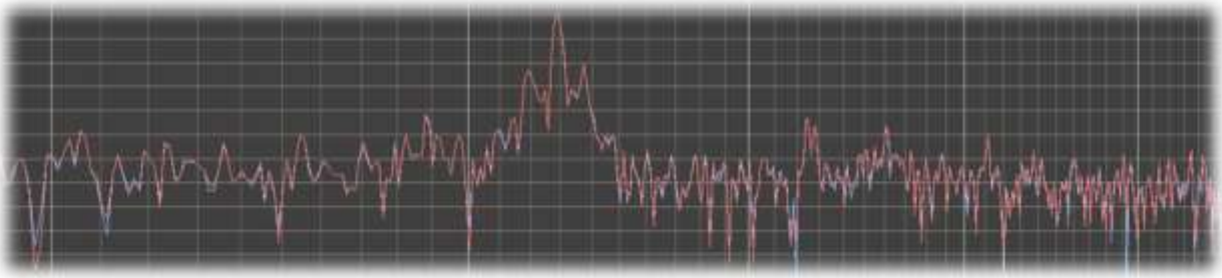


Figure 14 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 22 meters distance 30⁰ left from the microphone pick up unit as shown.

Figure 14. FET analysis of the results at 22 meters 30⁰ left.

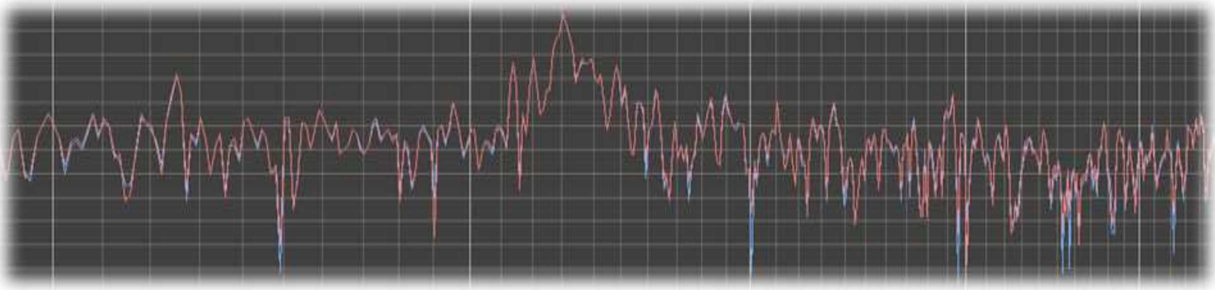


Figure 15 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 22 meters distance 30⁰ right from the microphone pick up unit as shown.

Figure 15. FET analysis of the results at 22 meters 30⁰ right.

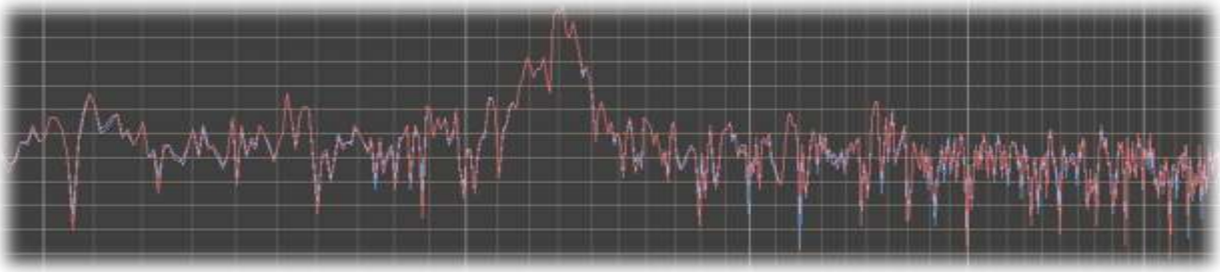


Figure 16 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 28 meters distance 30⁰ left from the microphone pick up unit as shown.

Figure 16. FET analysis of the results at 28 meters 30⁰ left.

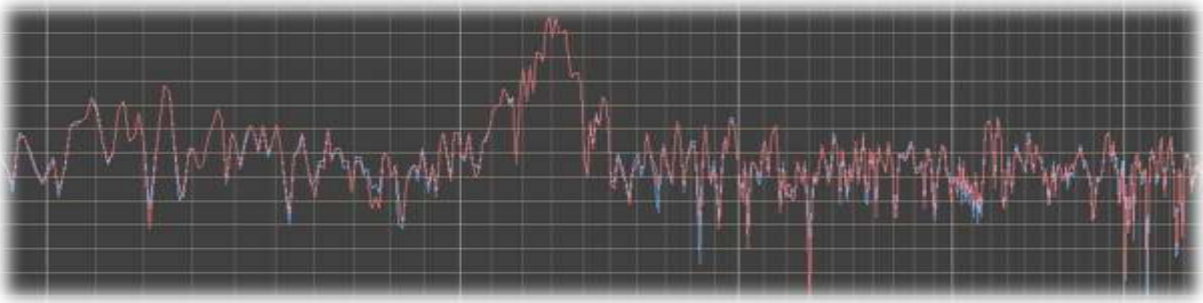


Figure 17 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 28 meters distance 30⁰ right from the microphone pick up unit as shown.

Figure 17. FET analysis of the results at 28 meters 30º right.

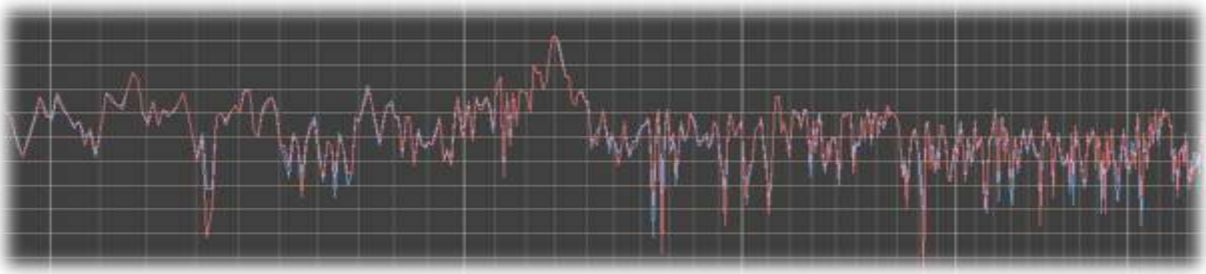


Figure 18 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 34 meters distance 30º left from the microphone pick up unit as shown.

Figure 18. FET analysis of the results at 34 meters 30º left.

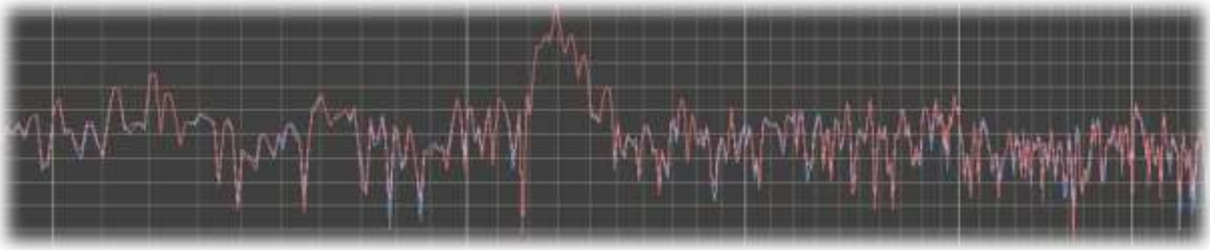


Figure 19 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 34 meters distance 30º right from the microphone pick up unit as shown.The FFT process, central to this analysis, plays a critical role as it transforms the sound's time-domain waveform into a frequency-domain representation. Through this transformation, the figure unveils the various frequency components that comprise the sound, facilitating an in-depth examination of its spectral characteristics.The selection of both a considerable distance and an angular offset of 30 degrees is a significant aspect of this analysis. It takes into account the principles of sound propagation over distance and the directional orientation's influence on sound capture. Factors such as sound attenuation, variations in frequency distribution, and the spatial characteristics of the environment are all considered. This approach allows researchers to gain a deeper understanding of how the sound marker's spectral properties evolve under these specific conditions.

FET analysis of the results at 34 meters 30º left.

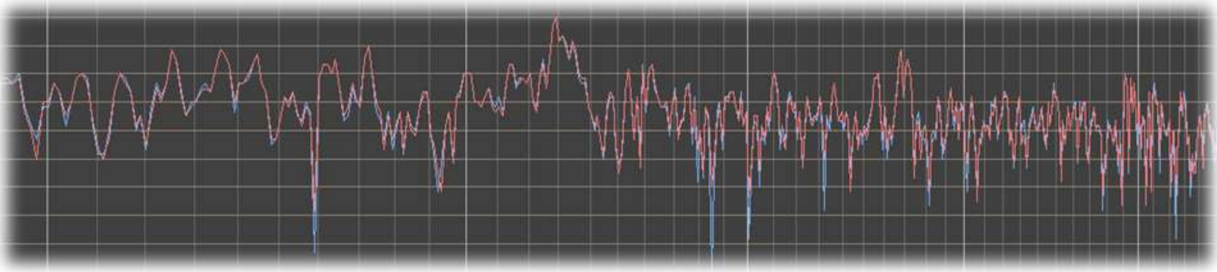


Figure 20 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 40 meters distance 30º left from the microphone pick up unit as shown.The FFT process is central to this analysis, as it transforms the sound's time-domain waveform into a frequency-domain representation. This transformation reveals the various frequency components that make up the sound, enabling a comprehensive examination of its spectral characteristics. The choice of both a considerable distance and an angular offset of 30 degrees is a critical aspect of this analysis. It takes into account the principles of sound propagation over distance and the directional orientation's impact on sound capture. Factors such as sound attenuation, variations in frequency distribution, and the spatial characteristics of the environment are all considered. This approach allows researchers to gain a deeper understanding of how the sound marker's spectral properties evolve under these specific conditions.

Figure 20 FET analysis of the results at 40 meters 30⁰ left.

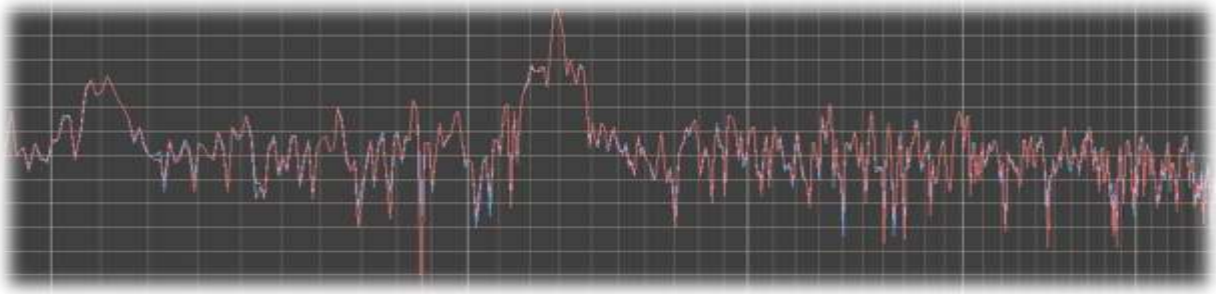
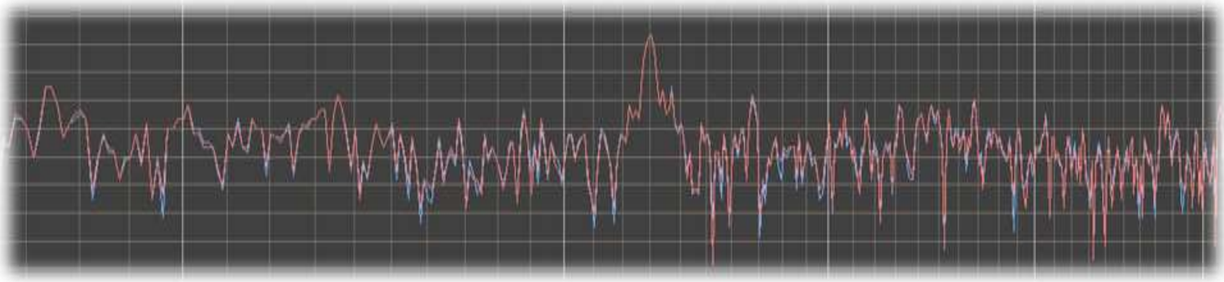


Figure 21 presents the waveform (in red) in Fast Fourier Transform frequency analysis of the original sound marker at 40 meters distance 30⁰ right from the microphone pick up unit as shown.The FFT process is central to this analysis, as it converts the sound's time-domain waveform into a frequency-domain representation. This transformation reveals the various frequency components that constitute the sound, enabling a thorough examination of its spectral characteristics. The selection of both a substantial distance and an angular offset of 30 degrees is a critical aspect of this analysis. It takes into account the principles of sound propagation over distance and the impact of the directional orientation on sound capture. Factors such as sound attenuation, variations in frequency distribution, and the spatial characteristics of the environment are all considered. This approach allows researchers to gain a deeper understanding of how the sound marker's spectral properties evolve under these specific conditions.

Figure 21 FET analysis of the results at 40 meters 30⁰ right.



4. Conclusion

It In view of the findings, the following conclusions were drawn:

1. The prototype gadget known as “directional telescopic microphone” is capable of detecting sounds which are not normally heard by human ears.

2. The sound waves are evident in all test results using original sound marker at different distances and at 30 degrees angle (left and right of the microphone pick up unit).

Recommendation

In the light of the findings and conclusions drawn in this study, the following recommendations are offered.

1. The gadget will be used in ecosystem bio-diversity studies in support for determination and preservation of the protected species.

2. Further studies for the improvement of the control unit to further enhance the frequency response.

3. Further studies should be conducted related to this concept idea.

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